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AUTHOR Ragan, Tillman J.
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ABSTRACT

In a field such as instructional design, explanations of educational outcomes must necessarily consider multiple input variables. To adequately understand the contribution made by the independent variables, it is helpful to have a visual conception of how the input variables interrelate. Two variable models are adequately represented by a two dimensional matrix; whereas, three-way approaches are better visualized as cubes whose edges represent different degrees of input factors. For other multifactor combinations, polyhedrons with the appropriate number of sides can provide a visual suggestion of how multiple factors interact with one another. (EMH)

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A Multifactor Approach to Research in Instructional Technology

Tillman J. Ragan
The University of Oklahoma

Introduction

This paper will attempt to cast some implications of the work in visual aptitude previously presented into a framework for thinking and further development. In what is to follow, no attempt will be made to add to the visual aptitude area itself, but to present a view of how that area may be productively studied within the broader world of instructional design. What is posited here is that there are many identifiable factors which operate in concert in any intentioned learning event, including activities designed to foster visual language development; and that there is a need for multivariate models employing as many factors as can be dealt with from a reasoned perspective.

The process of generation of multifactor research efforts in instructional technology may undoubtedly proceed in a number of radically different ways and from varying geneses. In this paper, the generation of a multifactor model will be outlined in three phases: (1) Factor Identification and Analysis, (2) Intermediate Multifactor Analysis, and (3) Full Multifactor Analysis. The purpose of the model is primarily illustrative and its topic is the frame of reference in which a theory of instructional technology may be seen to operate. The model is far too tentative and broad to be considered as a prescriptive effort, yet I hope it is amenable to refinement toward that end.

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Phase I: Factor Identification and Analysis

At issue here is the perhaps unanswerable question of what set or list of factors adequately or best encompasses relevant variables in learning and instruction. Unanswerable or not, the question is one approached in one fashion or another as a matter of course in instructional development efforts. In an effort to generate such an identification of factors, one might look at what factors are modeled or dealt with in some fashion or another in widely applied instructional development models. This approach to factor identification was taken by Dunn and others in a working paper on instructional technology research (Dunn, et. al., 1974). One might next attempt to refine such a list from the standpoint of theoretic utility--for example, to ask the question, "What sense do these factors make as areas under which researchable questions may appear?" Concurrently, an assessment must be made of what is and is not known under each area, in what alternative structures and subordinate areas. For example, one might generate from such an analysis a list of broad areas which would include characteristics of (1) Learners, (2) Learning Tasks (content, objectives), (3) Purposes, (4) Delivery Systems (teachers, media attributes), (5) Settings, and (6) Instructional Strategies. These are broad areas, to be sure, and each one is pregnant with both alternative conceptualizations and subordinate areas. For example, is it most productive or useful to an instructional theory structure to place content and objectives under the ruberic of "learning task analysis" or as separate areas? In another instance, should the delivery system area be replaced by separate consideration of "media attributes" and "teacher attributes?" I do not pretend to know what the best list would be but suspect some lists would be better than others and that the best of those would be better than

mine. The subordinate areas themselves pose questions of scope versus level of analysis. One might begin a list of potentially relevant learner characteristics for example, with such broad areas as information processing characteristics, cognitive style differences, intellectual development, aptitudes, prior learnings, cultural differences, and so on. And to begin to break any of the sub-areas out in any complete way humbles the mind. So, in whatever way such a list would be generated, and from whatever perspective it would be analyzed, suffice it to say for present purposes that a reasonable effort in this direction would be an inherently ambitious one if carried to any kind of conclusive end. Yet, the unanswerable question does not have to be answered to be approached. Practitioners do it every day. The purpose of this first phase is to address with as much reason and power as can be mustered the real world of instruction and learning from an analytic standpoint.

Phase II: Intermediate Multifactor Analysis

Two sorts of multifactor approaches are seeing wide application in present research in instructional technology: two-way and three-way. By two-way analyses I refer to the sort of approach taken by aptitude treatment interaction (ATI) or trait treatment interaction (TTI) work, and as examples of three-way multifactor approaches, the various lines of work which tend to be represented as cubes.[1]

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[1]It should be recognized that ATI work or anyone's three-way model is seen as "intermediate level" in this conceptualization only. For researchers working in these areas, such a conceptualization may be invalid and unfair. To impose the structure I present as a replacement for more focused work is not the intent here; only to propose an alternative conceptualization for those interested in the breadth of scope which this proposal will offer.

a. Two-way Approaches. To expand somewhat on the possibilities of two-way approaches, including but not limited to the ATI model, an unconventional sort of matrix application may be employed (see Figure 1). In applying the same set of factors on both axes, as would more commonly be done in correlational displays, the matrix produced forces all possible two-way combinations from a list. Applying the six-area example presented in Phase I, fifteen different factor combinations are created (excluding cells which merely duplicate or reverse the order of terms). Each cell creates an empty box in which a two-way factorial research design may be built. The ATI approach appears in this matrix as cell No. 11, "learner by strategy" or perhaps in cell No. 4, "learner by delivery system." Most of the other cells in this matrix imply, given the breaking-out of broad areas into variables, questions of interest equal to those posed by ATI research. For example, cell No. 1, "learner by learning task," presents a combination of factors which are commonly taken as a basis for work in inquiry method, where the learner's intellectual development (e.g., in the Piagetian sense) is the learner characteristic of interest, and development of higher-order intellectual skills or "rational powers" is the learning task. Cell No. 12, "learning task by strategy" has also been of considerable interest in, among other lines of work, development, validation, and application of learning heirarchies to instructional design. Merrill's "dynamic learner control general strategy" appears, if I understand it correctly, as cell No. 14, "strategy by delivery system." (Merrill, 1975). As a final example of two-way analyses, work in the area of environmental design in education, as summarized nicely in Krasner's "The Classroom as A Planned Environment" (Krasner, 1976), seems to logically and meaningfully be put in cells 7, 8, 9, 10, and 15, or, setting by learner, learning task, purpose, delivery system, and strategy.

b. Three-way Approaches. It would appear that researchers in educational technology have become enamored of hexahedrons (cubes). While Guilford was undoubtedly not the first person to cast a three-way interaction matrix into a cube-shaped model, his Structure of Intellect is certainly a widely emulated example (see Figure 2). Some examples of three-way multi-dimensional models in educational technology are shown in Figure 3. Clark's Media Taxonomy Cube (Clark, 1975); Figures 4 and 5. Schalock's models of Substantive Outcomes and of Process Outcomes (Schalock, 1972); Figure 6, Ausburns' Media Design Model (Ausburn and Ausburn, 1976); and Figure 7, A Model for Generating Research Questions in Instructional Technology (Dunn et. al., 1974). Each of these models seems to represent an attempt to pull together and, in a sense, force meaningful interrelationships between factors. At the risk of being too flippant, any reader may create, publish, and get deserving fame from his or her own cube-shaped model. Take any three factors from the six above and put them together on a cube. If they represent a previously un-studied combination of areas or, even if previously studied in a three-way factorial sense, a previously un-modeled combination, you may have something. Of course the three factors one selects must make sense. Some combinations may make more sense than others, and some combinations will generate higher-impact or higher-priority questions than others. But I do believe you are relatively safe in coming up with a combination in which interrelationships posing researchable problems may be generated. That is because (h) any intentioned learning event, each of the six factors is always there in some aspect, and no factor exists independently of the others.

Phase III: Full Multifactor Analysis

The stance taken here is that the actual number of critical factor sets far exceeds the artificial limitation imposed by the three visible faces of

a cube when used as a representational device. However, the kind of interrelationships which are so well-modeled with the commonly employed cube are highly useful conceptually. The model proposed here is one which utilized cubes as intermediate-level stages of multifactor combination. At full levels of multifactor combination, I must become tentative in proposing a comparable visualized representation which would be, to me, as fully comprehensible and defensible as the relationships displayed by a simple cube. However, regular polyhedrons of 8, 12, 20 and more sides can be drawn and utilized as visualizers to assist in initial conceptualization of complex multifactor interactions. An opaque twelve-sided regular polyhedron (dodecahedron) yields six visible surfaces in a frontal view. The six factors previously used as examples may be applied to the six visible sides of a dodecahedron to produce a model of the simultaneous interaction of six separate but interrelated variables in instruction (see Figure 8).

The data processing technology and quantitative methods for analysis of multifactor interactions such as are implied by this model are available. Techniques derived from multiple regression models such as multiple correlation, canonical correlation, and multiple discriminant analysis can be appropriate heuristic tools. It should be noted that questions of discrete and continuous variables, predictor and criterion variables, and other sometimes difficult conceptual/procedural matters are not approached by this model. At any rate, these are questions of multivariate research which must be dealt with, dodecahedron model or not, and the model neither gives answers to them nor precludes their resolution. Finally, the interpretation problems created by multivariate analyses of this scope can be immense. The only hope of a way out is to insure that in hypothesizing relationships to be investigated, adequate theoretic rationale exists which gives reason to believe the hypothesized relationship exists.

Conclusion

I am convinced that any fully adequate theory of instructional technology must address itself to matters such as the interactions between characteristics of learners, psychological requirements of what they are learning, for what differential purposes, using what delivery system(s), under what setting conditions, and as implemented through what strategy or strategies.

The multifactor model which this paper has outlined is, as much as anything else, a vehicle for illustration of directions for research in instructional technology. That direction would be toward attempts to investigate the interactions of as many critical dimensions of learning and instruction as may exist. The six factors used as extended example throughout this paper, as well as the dodecahedron shape onto which they were cast, are purely in the way of illustration. Much is known about each of the six factors used as illustration here, and much is not known. Much of what is not known will best be found through theory-based investigations of single factors and through investigations of them or their cousins in pairs and in triads. The knowledge thereby gained will contribute to, but ultimately fall short of, filling the need. We need the ability to predict the effects of our instruments, strategies, treatments or whatever it is we propose to do in fostering intentioned learning or development. We need that ability across all possible settings, for varying purposes, for all learners. Not just for elementary school science, or for high school mathematics, or for technical training in electronics, or for graduate level studies in literature. Instructional technology needs a more fully adequate theory. In its absence, models are needed which cast the scope or framework for theory building into a more realistic perspective.

One might question the timliness of the proposal implied here. Should we not, it might be asked, focus efforts on matters of less scope, matters of a less speculative nature (at present levels of development) than the relationships among the wide-ranging scope of factors proposed? In response, I would reiterate that the breadth implicit in my position does not substitute for focused interest in a given variable, target population, or discipline. I would hope, however, that some will begin to make vigorous attempts to start looking at the whole world of instruction in systematic and theoretically well-grounded ways.

	Learner	Learning Task	Purpose	Delivery System	Setting	Strategy
Learner						
Learning Task	1					
Purpose	2	3				
Delivery System	4	5	6			
Setting	7	8	9	10		
Strategy	11	12	13	14	15	

Figure 1. Possible two-way combinations from a list of factors in instruction.

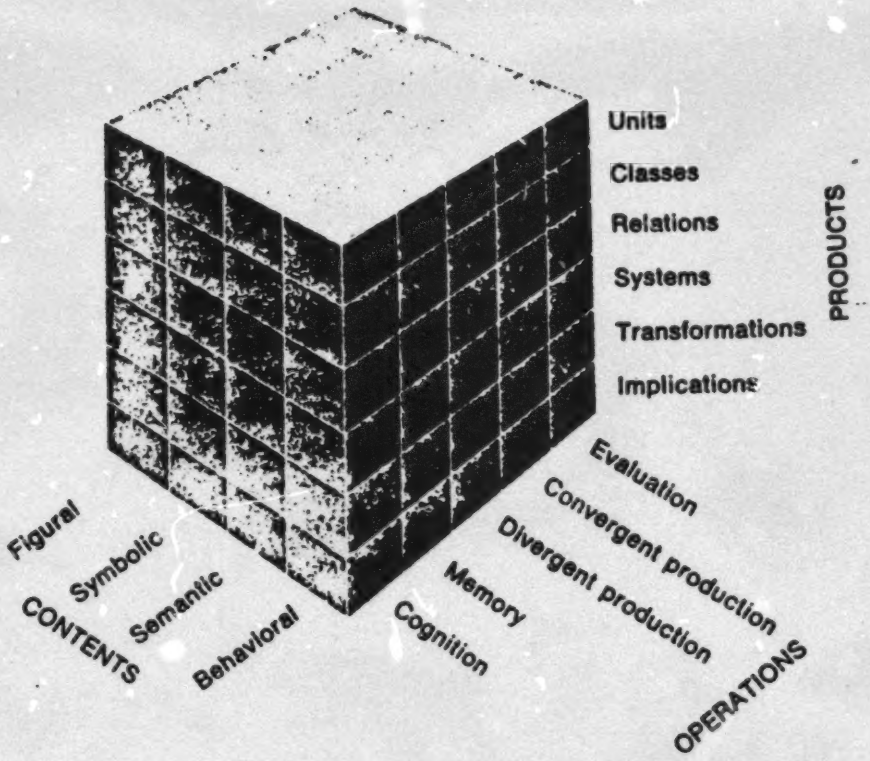


Figure 2. Guilford's model for the complete Structure of Intellect (Guilford, 1959).

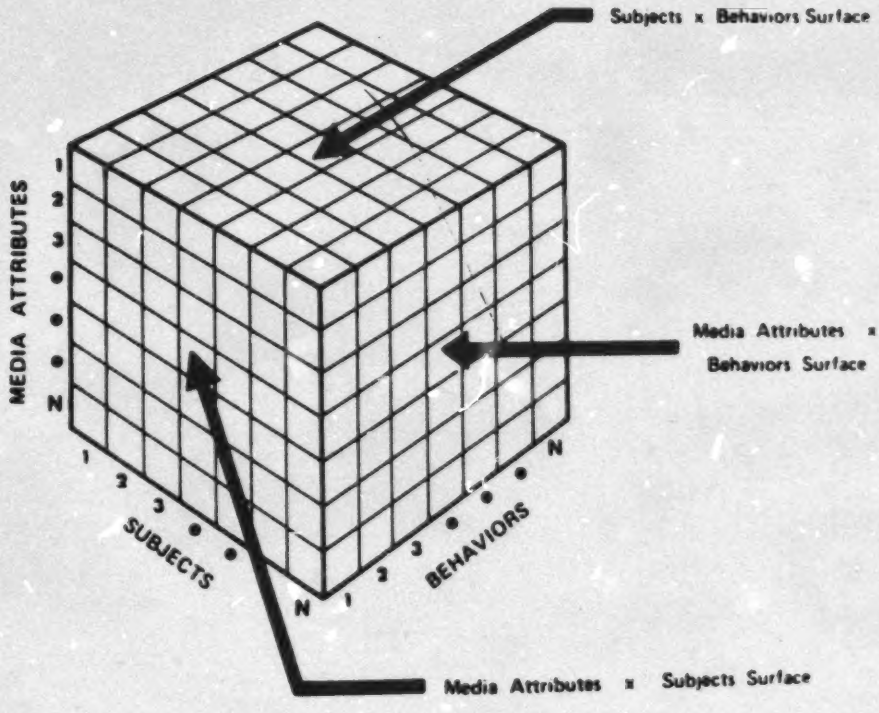
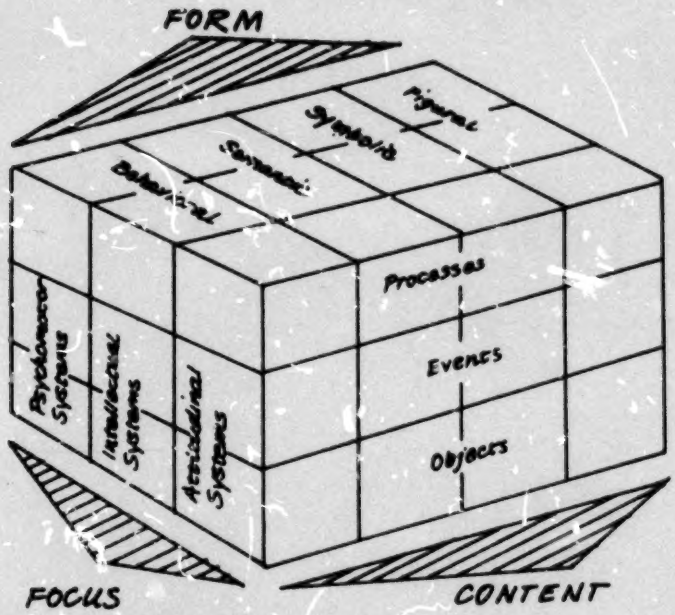
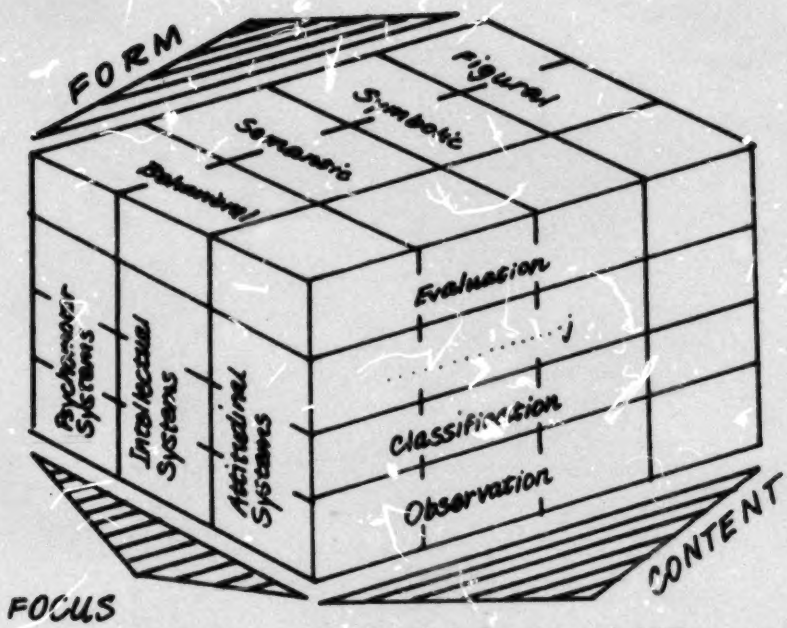


Figure 3. Clark's media taxonomy cube (Clark, 1975).



A three dimensional model of substantive outcomes.

Figure 4. Schalock's model of substantive outcomes (Schalock, 1972).



A three dimensional model of process outcomes.

Figure 5. Schalock's model of process outcomes (Schalock, 1972).

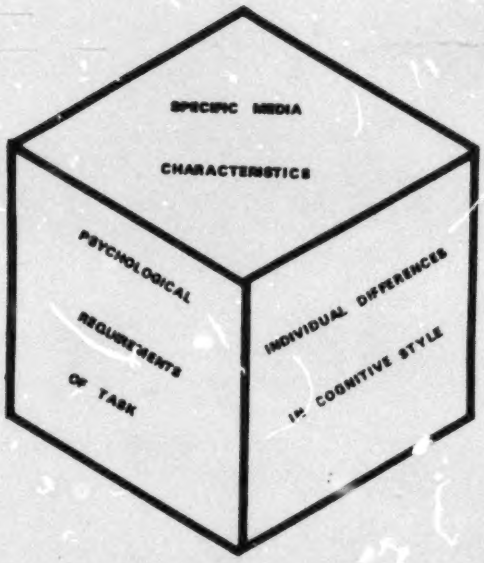


Figure 6. Ausburns' media design model (Ausburn and Ausburn, 1976)

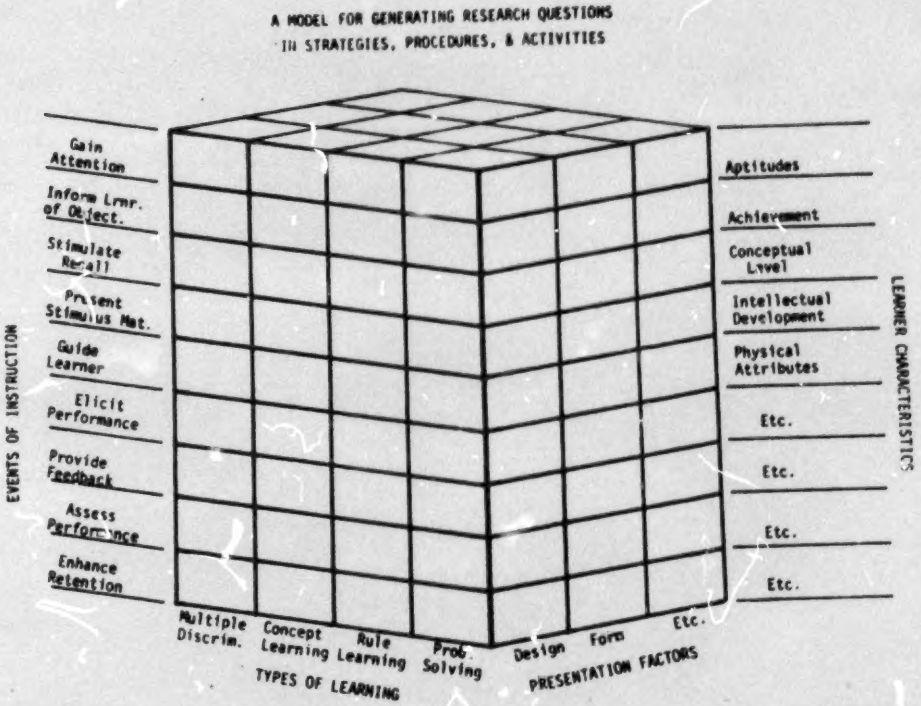


Figure 7. A model for generating research questions in instructional technology (Dunn, et. al., 1974)

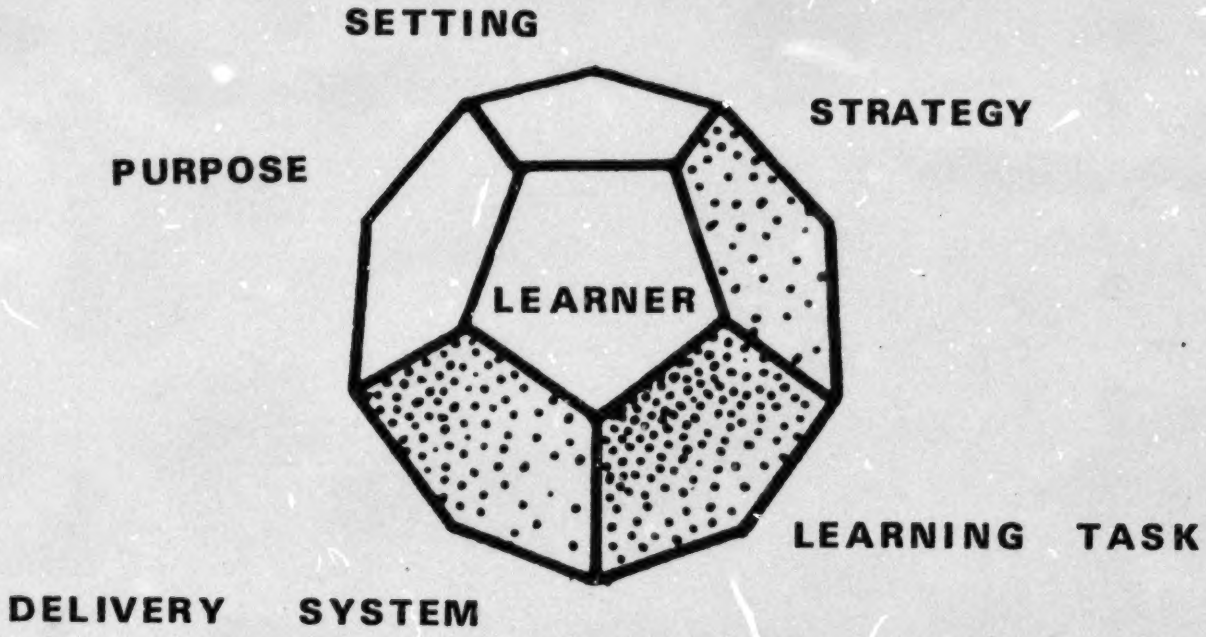


Figure 8. A multifactor model for research in instructional technology.

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